ENVIRONMENTAL RESTORATION

U.S. Army Environmental Center

Risk-Based Decision Making

Introduction

Risk-based decision making is an important component of the environmental restoration process. Risk-based decision making involves an explicit consideration of the source, pathway and receptor relationships at key decision points within the restoration process. The goal of risk-based decision making, as described in this Fact Sheet, is to ensure that Army resources are focused on reducing risk to the extent necessary to protect human health and the environment, at a cost commensurate with the risk reduction achieved.

This Fact Sheet discusses the key elements of risk-based decision making and provides references that can be used to enhance the project management team's understanding of the risk-based approach and assist in the practical implementation of risk-based decision making. Both human health and ecological effects can be considered within a risk-based decision making framework. This fact sheet focuses on human health.

Background

Independent Technical Review (ITR) was implemented to promote cost efficiencies in the Army's restoration program. The main objective of the program is to identify opportunities for cost savings and avoidance while meeting our legal obligations and protecting human health and the environment. It is critical for the Army to find more cost-effective approaches to environmental restoration to reduce the flow of finite resources away from modernization and sustainment efforts. In fact the Army's fiduciary responsibility requires that an explicit legal or risk driver be identified before a site restoration project receives funding.

Based on ITR observations, it is clear that expanding the use of risk-based decision making across the Army's restoration program can result in significant cost savings as well as a more explicit demonstration of protection of human health and the environment. Relevant ITR observations are highlighted in Box 1.

BOX • 1

ITR Findings

ITRs at 18 of 27 Army installations identified possible cost savings that could be achieved by properly applying a risk-based approach to determine whether remedial action is warranted at a site.

At many of the installations, data was collected to characterize incomplete or inappropriate exposure pathways. For example, at 9 sites, risk was assessed for unnecessarily conservative future exposure scenarios not represented in future land use plans; at 8 sites, risks from background levels of metals in soils were included in determining the need for remedial action; and at 10 sites, a conceptual site model had not been developed and used to focus data collection activities.

Other commonly observed problems included:

1. Using USEPA Maximum Contaminant Levels (MCLs) as cleanup criteria for groundwater where naturally occurring conditions (such as elevated salinity or low yield) would not support potable use; and
2. Improperly using generic criteria or standards to drive remedial action, irrespective of a site-specific risk assessment.

What is Risk-Based Decision Making?

In the context of site restoration, risk-based decision making is a process that relies on an explicit consideration of exposure, chemical toxicity, and potential health risk to help determine the proper scope of remedial actions. Two basic questions are asked:

- Does contamination at the site pose a risk great enough that remedial action is necessary?
- If remedial action is necessary, what is the appropriate type and extent of action?

A simple, non risk-based approach to addressing these question might involve an initial comparison of concentrations measured at the site to generic criteria, such as published regulatory screening criteria or "background" (i.e. unaffected) conditions. If the measured concentrations exceed these criteria, then the lowest cost action that can reduce site concentrations to the generic criteria is taken. This type of approach is sometimes referred to as "technology-based", because it is driven primarily by an evaluation of technologies to achieve prescribed, non site-specific cleanup levels.

Experience at Army installations demonstrates that attaining generic criteria at industrial properties or waste management sites can be prohibitively expensive, and is sometimes technically impracticable. Risk-based strategies allow for identification of remedies that are protective of human health and the environment but are also cost-effective. Risk assessment when properly applied as an overall risk-based strategy, can be used to define chemical concentrations which may exceed generic regulatory criteria or natural background levels, but do not pose a significant threat given the intended future use of the site. It can also be used to objectively evaluate the relative risk reduction associated with various remedial actions, to balance against cost when selecting a remedy. An example of the technology-based approach compared to the risk-based approach is highlighted in Box 2.

Of course, restoration activities undertaken using a risk-based approach must still fulfill all legal require-

BOX • 2

Comparison of Technology-Based and Risk-Based Approaches

Data may indicate that concentrations of a chemical in groundwater at a site may exceed the USEPA Maximum Contaminant Level (MCL). Using a simple "technology-based" approach, various remedial actions would be evaluated in order to select a technology that can achieve the MCL at the lowest overall cost. By comparison, under a "risk-based" approach, the ways in which exposure to groundwater might occur, and the extent of such exposure, is considered before evaluating remedial action alternatives.

The MCL is based on a residential drinking water scenario, assuming long-term continuous exposure. However, existing laws or institutional controls may be in place that restrict use of private or public wells, or the aquifer may not be considered a potable water source because of low yield or the presence of naturally-occurring substances (e.g. high salinity or metals content).

If the groundwater does not reasonably represent a drinking water resource then attaining the MCL may not be necessary to protect human health or the environment and site-specific goals reflecting the types of exposure to groundwater contamination that could realistically be expected could instead be developed. If the groundwater is a current or potential drinking water source, then the MCL may be an appropriate goal, but it may be more cost effective and feasible to prevent exposure to the groundwater through institutional controls than to actively reduce chemical concentrations in groundwater. It may still, however, be necessary to meet or waive Applicable or Relevant and Appropriate Requirements (ARARs).

ments. Further, there may be instances when a cleanup to generic criteria is cost effective because overall remediation costs are low and would not be affected by site-specific evaluation. However, when remediation costs are potentially significant, a risk-based approach can, and should, be used to help determine the need for, and type of, remedial action at a site to ensure that human health and the environment are protected in a cost effective manner.

BOX • 3

Risk-Based Decision-Making in the RCRA Program

Certain cleanup actions at some installations are governed by non risk-based permit requirements or other legal obligations under RCRA. There is usually no requirement to conduct a site-specific risk assessment for such actions. For example, the closure of hazardous waste management units must follow the RCRA regulations for closure, which, among other things, require the removal of RCRA hazardous waste from the unit regardless of whether waste removal is necessary to protect human health or the environment. These obligations should be discussed with legal counsel and clearly understood before action is taken. Non risk-based regulations under RCRA usually have narrowly defined applicability, so that a precise understanding of the scope of the regulation is necessary to ensure that opportunities for risk-based decision making are not overlooked. In fact, the overriding mandate under RCRA, like that under CERCLA, is still protection of human health and the environment. EPA generally requires that risk assessments and remedial decisions follow the regulations and guidance issued under CERCLA (USEPA 1996a).

Regulatory Framework

Most restoration efforts at Army installations are conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA), or under programs that require substantive compliance with either CERCLA or RCRA. Some cleanups may be regulated under state programs that do not follow the CERCLA or RCRA process. For example, some state cleanup programs allow for a tiered approach to remediation, such as the one outlined in ASTM's Standard Guide to Corrective Action at Petroleum Release Sites (ASTM 1995). The ASTM tiered approach, commonly known as Risk-Based Corrective Action (RBCA), consists of three tiers of risk evaluation to determine a cost-effective and protective site remedy. As in CERCLA and RCRA, issues that affect the scope of the risk evaluation, such as land and groundwater use, should be addressed in Tier 1 or Tier 2 of the RBCA process. However, site-specific data and refined exposure modeling are not typically incorporated until a higher tier (e.g. Tier 3) of a RBCA process.

The key concepts discussed below in the context of CERCLA are generally applicable to all cleanup programs, including those based on a tiered approach. (Some exceptions for cleanups under RCRA are highlighted in Box 3).

Risk-Based Approach – Steps in the Process

For over two decades, the process of risk assessment has been used and accepted by regulatory agencies as an objective means of identifying sites that may need remediation and as a tool to help determine the most appropriate remedial action. The risk-based approach supported by the ITR is consistent with the CERCLA and RCRA site investigation and remediation programs, as outlined in the regulations and in regulatory guidance documents.

A key element of the ITR approach is to reduce uncertainties in those portions of the risk assessment that drive site restoration decisions, by collecting and using site-specific data and information. In this way, cost-effective risk management decisions can be based on site-specific considerations, rather than conservative assumptions that may drive unnecessarily stringent cleanups. The risk assessment process promoted by the ITR is not simply conducting a risk assessment; it is a process that begins during the initial site assessment and continues through the remedy selection, implementation, and monitoring. At many critical junctures in the remediation process, an explicit consideration of exposure and risk can help focus on those activities that will drive risk-based remedy decisions. The key decision points and recommendations for decisions to be made are summarized in Box 4. These points are discussed in more detail below.

Project Scoping/RCRA Facility Assessment (RFA)

The objective of project scoping is to define more specifically the type and extent of subsequent investigation that is appropriate at a site. A preliminary characterization at this stage is based on readily available information, to help identify the types of additional data that are needed, and design efficient studies to collect these data. In order to apply risk-based decision making, key elements of project scoping include: 1) land use/ground water use determination; and 2) initial conceptual site model (CSM) development.

1 Land Use/Ground Water Use Determination

Land use and ground water use assumptions can strongly affect the types of data that are collected in the RI/RFI, the exposure pathways that are evaluated in the baseline risk assessment, and the types of remedial action considered in the FS/CMS. Thus, USEPA encourages early determination of reasonably anticipated future land use to focus subsequent data collection and analysis at a site, and streamline the development of remedial alternatives (USEPA 1995). The Presidential/Congressional Commission on Risk Assessment and Risk Management also specifically recommends that reasonable assumptions about future land uses at a site be developed early and used in risk assessments and risk management decisions (Presidential Commission 1997). Box 5 highlights sources of information that can be used to determine reasonable future use at a site.

In many cases, residential use is the least restricted land use, with the greatest potential for human exposure. Thus, the most stringent cleanup goals and costly remedial alternatives are required when it is assumed that residential use of a site is reasonably anticipated. However, according to USEPA (1990), "the assumption of future residential land use is not a requirement" and "may not be justifiable if the probability that the site will support residential use in the future is small." In such circumstances, subsequent RI/RFI and FS/CMS activities should conform with expected future conditions, such as industrial or commercial land use, based on site-specific factors.

It is generally assumed that future land use at an active installation will be of the same type as current land use, unless otherwise indicated in the installation master plan. Under the Base Realignment and Closure (BRAC) program for installations that will not be under Army control, there is a preference for future use to be as unrestricted as possible; however, in some cases cost and technical feasibility may limit the future use of an area. For example, the transfer of

BOX • 4

Key Decisions in the Risk Based Approach

Project Scoping

1. Identify current and reasonably anticipated future land and groundwater use to determine scenarios under which exposure and risk may occur.
2. Develop an initial conceptual site model (CSM) based on current and reasonable future land use.

Remedial Investigation (RI)/RCRA Facility Investigation (RFI)

1. Use the CSM to focus site characterization activities on the minimum amount of data needed to determine the nature and extent of site-related threats to human health and the environment.
2. Conduct a baseline risk assessment consistent with the CSM and land use considerations to determine whether potential risks warrant remedial action. For critical exposure scenarios that may drive remediation decisions, use site-specific data and information to the extent possible. Include the following considerations:
   - assess risk over an appropriate exposure area, rather than sampling location by sampling location;
   - assess risk using a conservative estimate of the average exposure concentration, not a maximum concentration;
   - consider remedial action to address human health threats only at sites where the cancer risk exceeds 10^{-4}, or the non-cancer hazard quotient exceeds 1.

Feasibility Study (FS)/Corrective Measures Study (CSM)

1. Minimize the use of conservative assumptions during development of cleanup goals as well as during the baseline risk assessment. Assumptions that may have a relatively small effect on the conclusion of the baseline risk assessment can have an important impact on cleanup goals. For example, an assumption that increases estimated risks by a factor of two may not substantially effect the conclusions of the baseline risk assessment but could eventually lead to cleanup criteria that are twice as stringent.
2. Incorporate the concepts of areal and temporal averaging into remediation plans. Compare cleanup levels to a conservative estimate of the average concentration across an exposure area rather than to the results at each sampling point.
3. Use risk-based triggers to differentiate "principal threat" materials, which may require removal or treatment, from "low-level threat" materials, which typically require containment rather than treatment or removal.
4. Explicitly consider the short-term risks that may be generated while implementing a remedy and balance against the long-term risk reduction potentially afforded by the remedy. In some cases, the short-term risk of implementing a remedy can actually be greater than the long-term risk reduction associated with the remedy.

a range for unrestricted use will be rare. Land reuse authority and the environmental program managers should discuss possible, likely and preferable future land uses early in the restoration process, preferably before investigation activities are conducted, and certainly before remedial action decisions are made.

2 Initial Conceptual Site Model (CSM) Development

Use of a CSM to guide decision-making is a key element of the risk-based approach to site investigation and remediation. The CSM provides a representation of environmental conditions at a site, and identifies sources of contamination, concentrations of specific chemicals in contaminated media, transport mechanisms, and potential exposure pathways and receptors. Remedial action should be considered only for those sources of contamination that have a complete pathway of exposure to a potential receptor. Thus, the CSM should establish exposure scenarios at a site that are consistent with reasonably anticipated future land and ground water uses on-site and off-site.

Under a risk-based approach, an initial CSM should be developed during project scoping based on readily available information, and updated as additional information becomes available during the RI/RFI and FS/CMS (USEPA 1990). Based on ITR experience, however, many installations fail to develop or use a CSM until well into the RI/RFI process or even beyond, and thus fail to use the CSM as a tool to streamline and reduce the costs of site investigation.

ITR experience indicates that the greatest restoration costs are typically associated with existing or potential future ground water contamination. At installations where ground water impacts have occurred or are expected to occur, and exposures to contaminated ground water are reasonably anticipated, the CSM should incorporate an understanding of the geology and hydrogeology of the site. On-site and off-site ground water use scenarios should be developed in the initial CSM based on: (1) an understanding of the reasonably expected ground water uses in the region; (2) state and federal ground water policies and regulations; and (3) existing knowledge of the site and regional hydrogeology. Once the initial CSM has been developed as far as practical with existing data and information, then knowledge gaps critical to application of the CSM in the remedy decision-making process should be identified.

Remedial Investigation (RI)/RCRA Facility Investigation (RFI)

The primary objectives of the RI/RFI are to collect and evaluate data to determine the nature and extent of threats the human health and the environment, and assist in the evaluation of remedial alternatives in the FS/CMS. In order to apply risk-based decision making, key elements of RI/RFI generally include: 1) focused site characterization; and 2) baseline risk assessment.

1 Focused Site Characterization

Site characterization serves a number of different purposes. Data are collected to determine physical characteristics of the site (e.g. soil characteristics and groundwater movement), identify the nature and extent of contamination, provide data for the risk assessment, and support the design of remedial alternatives. However, using a risk-based approach, sampling should concentrate on characterizing the nature and extent of threats to human health and the environment, rather than the nature and extent of contamination. Sampling efforts can often be reduced in scope if they are tailored to an overall risk-based decision making strategy focused on those pathways that are identified in the CSM as complete or expected to be complete under reasonable future use scenarios. For example, many installations assume that meeting generic criteria (such as MCLs, or state-wide guidance values) will be required, and therefore investigations are conducted to identify all contamination present above these generic criteria. This can lead to unnecessarily extensive characterization of nature and extent of contamination without consideration of source/

BOX • 5

Determining Future Land Use

In 1995, the USEPA Office of Solid Waste and Emergency Response (OSWER) issued OSWER Directive No. 9355.7-04, entitled "Land Use in the CERCLA Remedy Selection Process (USEPA 1995). This guidance presents a framework and specific factors to be used in determining the reasonably anticipated land use for the purpose of estimating future risks. Historical and current land use, supported as needed by local land use development patterns, visual inspection of the site, and a review of the sources and types of information identified in USEPA (1995) guidance, should be used to establish reasonable anticipated future use at the site. In some cases conditions at the site (e.g. the presence of unexploded ordnance) may influence the range of possible future uses. Other sources of site-specific information may include the installation master plan; the master plan for the city or town; zoning maps; demographic data; topographic, wetland inventory, and flood plain maps; and information from historic landmark foundations. For groundwater, existing laws or well installation restrictions can prevent the use of groundwater as a drinking water source. In some cases the aquifer may not be potable because of its low yield or the presence of naturally occurring substances (e.g. high salinity or metals content).

pathway/ receptor relationships. The CERCLA process actually requires that a risk be identified before identifying Applicable or Relevant and Appropriate Requirements (ARARs), such as MCLs for ground water. Preliminary identification of exposure routes and exposure points when the site characterization plan is developed can be used to identify the appropriate number, type, and location of samples needed to assess exposure. Collection of data in the RI/RFI should be used to confirm the presence of complete exposure pathways (as necessary) and provide the data necessary for evaluating potential future exposures and risks through these pathways. An uncertainty management strategy should be applied to identify data gaps that need not be resolved in order to make technically defensible decisions on risk and remedy identification. Quantitation limits should also be considered prior to site characterization since these are used in the risk assessment to estimate concentrations of site-related chemicals in 'nondetect' samples.

When preliminary sampling results become available, risk-based screening methodologies, such as EPA's Soil Screening Guidance (USEPA 1996b) or state-developed screening values, can be used to focus subsequent investigation on areas of the site that are more likely to be of concern. It may also be important to collect information on key properties of soil, ground water and other media to allow for the use of site-specific data, rather than generic defaults, in modeling conducted to support the baseline risk assessment under RCRA or CERCLA, or higher tier evaluations under a RBCA-type program.

2 Baseline Risk Assessment

Although any contaminated site can pose some level of risk to human health and the environment, not all sites with contamination require remediation. The baseline risk assessment is performed in the RI/RFI to determine whether contaminant levels at a site warrant further consideration of remedial action. The baseline risk assessment examines the current and future risks posed by a site in the absence of remediation, taking into account expected land use in the area, using assumptions and inputs that are believed to be more likely to overestimate rather than underestimate potential human health and environmental risks. To serve as the proper foundation for risk-based decision making, the baseline risk assessment must be consistent with the reasonable land use determination and focused CSM from project scoping.

The baseline risk assessment should incorporate information regarding behavior patterns and characteristics of individuals in the receptor population to estimate the chemical dose received through the identified exposure pathways. Constituent concentrations to which receptors could be exposed should be estimated using techniques that are consistent with the type and duration of exposure. For example, because a receptor is not likely to be exposed to the maximum concentration at a site continuously over several years, long-term exposures are usually based on a conservative measure of the average concentration. Thus, areal and temporal averaging should be considered in evaluating exposures to allow for appropriate risk-based decision making. For soils, long-term exposures would be expected to occur over an area (e.g., at least 0.25 acres for a residential scenario), rather than at one particular point (EPA 1989). Thus, it is appropriate to assess the risk using a conservative estimate of the concentration over the exposure area, rather than the concentration from a single sampling location. Similarly, ground water pumped from a well would be drawn from an area rather than from a single point in the aquifer; thus, the average ground water concentration over the well's recharge area, rather than the maximum concentration, should be used to calculate long-term exposure and risk.

The results of the baseline risk assessment should be compared to appropriate benchmarks to determine if remedial action should be considered at a site. For example, OSWER Directive 9355.0-30 identifies levels of risk that should be used as benchmarks for determining if further corrective action at a site should be considered. According to EPA (1991a), "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action is generally not warranted unless there are adverse environmental impacts." More stringent benchmarks should be applied only if required by state or federal law.

Feasibility Study (FS)/ Corrective Measures Study (CMS)

The primary objective of the FS/CMS is to provide decision-makers with a comparative assessment of remedial alternatives and allow for the selection of a remedial action that cost-effectively protects human health and the environment and meets legal requirements. In order to apply risk-based decision making, key elements of FS/CMS generally include: 1) formulation of risk-based preliminary remediation goals (PRGs) and final cleanup levels; 2) use of risk-based triggers to differentiate "principal threat" materials from "low level threat" materials; and 3) considering the long-term risk reduction and the short-term risk that may be generated while implementing a remedy. Risk-based decision-making also often includes an explicit balancing of risk reduction and cost to highlight for selection only those remedies that can attain risk management objectives in the most cost-effective manner.

1 Risk-Based PRGs and Final Cleanup Levels

If remediation at a site is deemed necessary, cleanup criteria must be identified that represent an "acceptable" level of residual concentrations in the affected media (USEPA 1991b). Risk-based cleanup levels are usually developed using the basic methodologies and assumptions applied in the baseline risk assessment. Often, cleanup levels are "back-calculated" to correspond to an overall risk goal for a site. This is achieved by setting chemical-specific cleanup levels equal to chemical concentrations believed to have no adverse effect on human health or the environment and which pose an "acceptable" or "insignificant" cancer risk.

There are several advantages to a risk-based approach for establishing cleanup target levels. First, risk assessment provides a scientifically defensible and increasingly accepted method for establishing cleanup levels that are protective of human health and the environment, considering site-specific factors. In contrast, the use of generic criteria (which are often not risk-based or developed based on assumptions that are not appropriate to the site being evaluated) may yield cleanup levels that are either not sufficiently protective, or are overly stringent and wasteful of limited resources for a particular site. A site that is expected to remain in industrial use and is located in a heavily industrial area need not be cleaned to the stringent levels appropriate for a residential area. Such distinctions allow for available resources to focus on conditions posing the greatest public health risk.

In many instances, the methodologies and assumptions used in the forward calculation of risk in the baseline risk assessment will be used in a backward calculation of cleanup goals. Thus, establishing proper assumptions regarding future land and groundwater use during the baseline risk assessment is critical to ensure that, if remediation is necessary, these assumptions will guide proper development of cleanup goals. Also, assumptions that have a relatively small effect on the conclusion of the baseline risk assessment can have an important impact on cleanup goals at the site. For example, an assumption that increases estimated risks by a factor of two may not substantially affect the conclusions of the baseline risk assessment, but could eventually lead to cleanup criteria that are twice as stringent. Box 6 highlights the relationship between the baseline risk assessment and the development of cleanup goals.

As previously discussed, the concepts of areal and temporal averaging can often be incorporated in developing, and remediating, to risk based cleanup levels. This concept of averaging should also be considered when applying the risk-based cleanup levels. In most cases, risk-based cleanup levels should be compared to a conservative estimate of the average concentration across an exposure area, rather than to the concentration detected at each sampling point. Thus, in developing remedial action plans, a conservative estimate of the average post-remediation concentration should be compared to the risk-based cleanup levels to ensure that the target risk level will not be exceeded after the remedial action is complete.

BOX • 6

Conservative Assumptions in the Baseline Risk Assessment and Development of Cleanup Goals

Based on ITR observations, Army installations sometimes conduct the baseline risk assessment using very conservative assumptions (i.e., assumptions likely to grossly overstate actual risk) in an attempt to avoid time-consuming negotiations with the regulatory agencies, particularly at sites where it appears that some type of remedial action will be necessary. However, it is important to avoid unnecessarily conservative assumptions throughout the process because, in addition to determining the need to take action at a site, the baseline risk assessment also plays an important role in establishing preliminary remediation goals at the outset of the remedy selection process. An overly conservative baseline risk assessment often leads to an unnecessarily stringent and potentially costly remedial action.

2 Identification of Principal Threat Materials

The appropriate remedy for a particular site can range from "no action required" to complete removal of contaminated materials with offsite treatment and disposal. An initial step in the selection of remedial alternatives is to determine whether treatment or containment is the primary objective. The National Oil and Hazardous Substances Contingency Plan (NCP) directly establishes EPA expectations for treatment. Specifically, EPA specifies the use of "treatment to address the principal threats posed by a site wherever practicable" and "engineering controls, such as containment, for waste that poses a relatively low long term threat" (40 CFR Section 300.430 (a)(1)(iii).

EPA expectations for remedy selection under RCRA corrective action include the use of "treatment to address the principal threats posed by a site wherever practicable and cost effective" (61FR 19432 at 19448, May 1, 1996). EPA has not established a "bright-line" threshold level of risk for identifying principal threat materials, but EPA guidance does clarify the role of risk assessment in helping to identify principal threats. Specifically, principal threats include materials "with toxicity and mobility characteristics that combine to pose a potential risk several orders of magnitude greater that the risk level that is acceptable for the current or reasonably expected future land use, given realistic exposure scenarios" (USEPA 1997). For example, according to USEPA, "where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater, generally treatment alternatives should be evaluated" (USEPA 1991c). Similarly, when considering non-cancer health effects, containment (rather than treatment) would be appropriate if the Hazard Index (HI) is less than approximately 100.

The concept of principal threats and EPA Guidance on this issue should be considered when selecting remedial alternatives, particularly in evaluating CERCLA's preference for treatment. Containment remedies, such as capping of contaminated soils, may be appropriate for materials that do not warrant treatment, but still pose an unacceptable risk to human health or the environment. Consideration of institutional controls may also be appropriate under certain site conditions. For example, land use restrictions could be considered when levels of contamination might pose a potentially significant risk under residential land use, but not under commercial/industrial land use.

3 Short-term Risk of Remedy

The risks created by remedy implementation at a site may include exposures to toxic chemicals; accidents associated with use of heavy equipment; heat stress caused by impermeable protective coveralls and use of respirators; and accidents or spills during off-site transportation of hazardous materials. The populations potentially at risk during implementation include on-site workers during site investigations and cleanup; off-site residents and workers in nearby areas; and crops, livestock, and wildlife in the vicinity of the site. In some cases, implementation risks can be significant, and may even exceed the long-term risks associated with a no-action remedy. For this reason, the 1990 NCP explicitly identifies potential remedy implementation risk as an important consideration in the remedy selection process at CERCLA sites (USEPA 1990). In addition, the USEPA has determined that a quantitative evaluation is useful at those sites where exposure levels are expected to change significantly as a result of remediation activities (USEPA 1991d, 1998).

Despite the clear intent of the NCP and the potential importance of remedy implementation risks, many assessments address the risks created by site clean-ups only qualitatively, if at all. Failure to adequately evaluate implementation risk during the remedy selection process can result in unanticipated risks to workers and nearby residents during cleanup, and in costly delays for substantial remedy modifications or abandonment of an incomplete remedy. Thus short-term implementation risks, such as those posed by extensive excavation activities or UXO clearance, need to be carefully evaluated and weighed against any long-term risk reduction that may be achieved. Guidelines for evaluating remedy implementation risks are presented in Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual (Part C, Risk Evaluation of Remedial Alternatives) (USEPA 1991d) and in Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments) (USEPA 1998).

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